CLAIMS

What is claimed is:

1. An optical enhancing material comprising a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold.

2. The material of claim 1 wherein said metal comprises at least one metal selected from the group consisting of silver, gold, copper, platinum, nickel, and aluminum.

3. The material of claim 1 wherein said metal particles have an average width between approximately 1 and 1000 nanometers.

4. The material of claim 1 wherein said metal particles and their clusters have lengths varying from the widths of individual metal particles to a lateral size of the metal film.

5. The material of claim 1 wherein said semicontinuous metal film has an average thickness between approximately 1 and 100 nanometers.

6. The material of claim 1 wherein said semicontinuous metal film has a metal-filling factor p over a range between $p_c - (\varepsilon_{\text{dielectric}} / |\varepsilon_{\text{metal}}|)^{0.36}$ and $p_c + (\varepsilon_{\text{dielectric}} / |\varepsilon_{\text{metal}}|)^{0.36}$, where p_c is a metal-filling factor at the percolation threshold, $\varepsilon_{\text{dielectric}}$ is a dielectric function, permittivity, of a dielectric component of the semicontinuous metal film, and $\varepsilon_{\text{metal}}$ is a dielectric function, permittivity, of a metal component of the semicontinuous metal film.

7. The material of claim 1 wherein said semicontinuous metal film is manufactured with at least one method selected from the group consisting of ion exchange, thermal evaporation, pulsed laser deposition, laser ablation, electron-beam deposition, ion-beam deposition, sputtering, radio-frequency glow discharge, and lithography.

8. The material of claim 1 wherein said material provides optical enhancement at light wavelengths between approximately 10 and 100,000 nanometers.

9. The material of claim 8 wherein said material provides optical enhancement at light wavelengths between approximately 200 and 20,000 nanometers.

10. The material of claim 1 additionally comprising an analyte placed proximate said medium.

11. The material of claim 10 wherein said analyte comprises at least one analyte selected from the group consisting atoms, molecules, nanocrystals, nanoparticles, and biological materials.

12. The material of claim 10 wherein said analyte is chiral.

13. The material of claim 10 additionally comprising a non-reactive surface coating placed over a component selected from the group consisting of said analyte, said medium, and both.

14. The material of claim 1 additionally comprising a microcavity / microresonator made of one or more materials selected from the group consisting of dielectric and semiconductor materials.

15. The material of claim 14 wherein said microcavity is selected from the group consisting of spheres, deformed spheres, spheroids, rods, and tubes.

16. The material of claim 14 wherein said microcavity is a semiconductor laser cavity.

17. The material of claim 14 wherein said medium is located at one or more surfaces of said microcavity selected from the group consisting of inner and outer surfaces.

18. The material of claim 14 wherein said medium is an integrated component of said microcavity.

19. An optical sensor comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; 356

a light source incident on said medium; and

one or more detectors of light emitted from said medium.

20. The optical sensor of claim 19 wherein said detector detects at least one signal selected from the group consisting of fluorescence, spontaneous emission, Raman scattering, Rayleigh scattering, Brillouin scattering, and nonlinear optical processes selected from the group consisting of stimulated Raman scattering, hyper-Raman scattering, hyper-Rayleigh scattering, multi-photon anti-Stokes emission, harmonic generation, sum-frequency generation, difference-frequency generation, optical parametric processes, multi-photon absorption, three- and four-wave mixing, and phase conjugation.

21. The optical sensor of claim 19 additionally comprising a microcavity / microresonator.

22. An optical sensing method comprising the steps of:

providing a doped medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; 356

locating the doped medium proximate a medium;

exciting the doped medium with a light source; and

detecting light emitted from said doped medium.

23. The optical sensing method of claim 22 wherein said detecting step comprises detecting at least one signal selected from the group consisting of fluorescence, spontaneous emission, Raman scattering, Rayleigh scattering, Brillouin scattering, and nonlinear optical processes selected from the group consisting of stimulated Raman scattering, multi-photon anti-Stokes emission, hyper-Raman scattering, hyper-Rayleigh scattering, harmonic generation, sum-frequency generation, difference-frequency generation, optical parametric processes, multi-photon absorption, three- and four-wave mixing, and phase conjugation.

24. The optical sensing method of claim 22 additionally comprising the step of employing a microcavity / microresonator.

25. A method of detecting an analyte material, the method comprising the steps of: 356

exciting both the analyte material and a medium in a vicinity of the analyte material, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold, with at least one light source; and

detecting light emitted from the material and medium.

26. The method of claim 25 wherein said detecting step comprises detecting at least one signal selected from the group consisting of fluorescence, spontaneous emission, Raman scattering, Rayleigh scattering, Brillouin scattering, and nonlinear optical processes selected from the group consisting of stimulated Raman scattering, multi-photon anti-Stokes emission, hyper-Raman scattering, hyper-Rayleigh scattering, harmonic generation, sum-frequency generation, difference-frequency generation, optical parametric processes, multi-photon absorption, three- and four-wave mixing, and phase conjugation.

27. The method of claim 25 additionally comprising the step of employing a microcavity / microresonator.

28. The method of claim 25 wherein the analyte material is selected from the group consisting of atoms; molecules; nanoparticles; chemical agents in water and atmosphere; biological agents in water and atmosphere; contaminations and environment hazards in the air, in water, in soil, at or near manufacturing sites, or at waste dumps; explosives; controlled substances; residual chemicals in foods; food poison; and chemical and biological agents in a body, bodily fluids, and wastes of humans and animals.

29. The method of claim 28 additionally wherein said molecules comprise chiral molecules.

30. A gratingless spectrometer comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

a light source incident on said medium; and

one or more near-field detectors of light emitted from said medium.

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31. A gratingless spectroscopy method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; 356

exciting the medium with a light source; and

detecting light emitted from said doped medium in the near-field zone.

32. A device for cryptography, coding and decoding information, said device comprising: 7

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; 359?

a light source incident on said medium;

one or more near-field detectors of light emitted from said medium; and

a logic component that compares a detected light pattern with an expected pattern.

33. A method for cryptography, coding and decoding information, the method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

exciting the medium with a light source;

detecting light emitted from said medium in the near-field zone; and

comparing a detected light pattern with an expected pattern.

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34. An enhanced optical limiting material comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and 7

an optical limiting material placed proximate the medium.

35. An enhanced optical limiting device comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and

an optical limiting material placed proximate the medium.

36. A microlaser comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; 385

an optically active material;

an energy source applied to said medium and said optically active material; and

a microcavity.

37. An optical amplifier comprising: 35 9 ?

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and

a light source incident on said medium.

38. The optical amplifier of claim 37 additionally comprising a layer of coating material selected from the group consisting of molecules, nanocrystals, and nanoparticles placed proximate said medium.

39. The optical amplifier of claim 37 additionally comprising a microcavity / microresonator.

40. An optical amplification method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

providing an input signal; and

exciting the medium with a light source.

41. The optical amplification method of claim 40 additionally comprising the step of providing a layer of coating material selected from the group consisting of molecules, nanocrystals, and nanoparticles placed proximate the medium.

42. The optical amplification method of claim 40 additionally comprising the step of providing a microcavity / microresonator.

43. An optical switch comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and

a light source incident on said medium.

44. The optical switch of claim 43 additionally comprising a layer of optical switching material selected from the group consisting of molecules, nanocrystals, and nanoparticles placed proximate the medium.

45. The optical switch of claim 43 additionally comprising a microcavity / microresonator.

46. An optical switching method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

providing an input signal; and

exciting the medium with a light source.

47. The optical switching method of claim 46 additionally comprising the step of providing a layer of coating material selected from the group consisting molecules, nanocrystals, and nanoparticles placed proximate the medium.

48. The optical switching method of claim 46 additionally comprising the step of providing a microcavity / microresonator.

49. A super density optical recording device comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

a layer of photosensitive materials placed proximate said medium;

a light source incident on said medium; and

one or more near-field detectors of light emitted from said medium and said layer of photosensitive materials.

50. A super density optical recording method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

providing a layer of photosensitive materials placed proximate the medium;

exciting the medium and photosensitive materials with a light source; and

detecting light emitted from said medium and photosensitive materials in a near-field zone.

51. A photochemical enhancing device comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and

a photochemical agent placed proximate said medium.

52. The device of claim 51 additionally comprising a highly porous dielectric matrix.

53. A photochemical enhancing method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

providing a photochemical agent placed proximate the medium; and

exciting the medium and photochemical agent with a light source.

54. The device of claim 53 additionally comprising the step of providing a highly porous dielectric matrix.

55. A photobiological enhancing device comprising:

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold; and

a photobiological agent placed proximate said medium.

56. The device of claim 55 additionally comprising a highly porous dielectric matrix.

57. A photobiological enhancing method comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

providing a photobiological agent placed proximate the medium; and

exciting the medium and photobiological agent with a light source.

58. The device of claim 57 additionally comprising the step of providing a highly porous dielectric matrix.

59. A sub-femtosecond pulse generation device comprising: 359

a medium, said medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

a light source, selected from the group of femtosecond pulses and white-light, incident on said medium; and

one or more near-field detectors of light emitted from said medium.

60. A method of generation of sub-femtosecond pulses comprising the steps of:

providing a medium, the medium comprising a semicontinuous metal film of randomly distributed metal particles and their clusters at approximately their percolation threshold;

exciting the medium with a light source selected from the group of femtosecond pulses and white-light;

detecting the sub-femtosecond pulses using one or more near-field detectors.